inches. The electrical path length to the fourth antenna is about 21 inches, and the path to the fifth antenna is about 22 inches.

The effect on the vertical radiation pattern of the antenna assembly **100** with the phase adjustment mechanism **108** set at this minimum downtilt position **1113** is to restore the downtilt angle to zero degrees, as illustrated in FIG. **10**.

Of course, adjusting the phase adjustment mechanism directly, by climbing an associated antenna support structure, would be nearly as inconvenient as adjusting the antenna mounting assembly to tilt the antenna. FIG. **14** depicts a remote control configuration for vertical radiation pattern downtilt adjustment.

With the antenna assembly **100** mounted in its normal operation position on a support structure, drive means, such as a drive mechanism **1401** is provided, mechanically connected to the movable coupling element of the phase adjustment mechanism **108**. The drive mechanism may be an electric motor, a resolver or servomotor, a stepping motor, or any of a number of known positioning devices. Control inputs **1403** for the drive mechanism **1401** may be provided from a remote location, such as a maintenance facility of the local service provider.

Position information **1404** is provided to the remote location by a position detector **1402**. The position detector may be implemented by Hall effect sensors, optical encoders, a synchro/servo system, or any of a number of other known position detection devices.

FIGS. **15** and **16** illustrate a plurality of antenna assemblies **100** (three) in accordance with the present invention supported in normal operating position by an antenna support structure **1501**, such as a tower. The antenna assemblies **100** are positioned such that the longitudinal axis of each antenna assembly **100** is substantially perpendicular to the earth's surface **1502**. Each assembly **100** is designed to cover a 120 degree sector of a cell and is adapted to be adjusted as described above.

There has been described herein an electrically variable beam tilt antenna that is relatively free from the shortcomings of prior art antenna systems. It will be apparent to those skilled in the art that modifications may be made without departing from the spirit and scope of the invention. Accordingly, it is not intended that the invention be limited except as may be necessary in view of the appended claims.

What is claimed is:

1. An antenna assembly having an operating frequency and a vertical radiation pattern with a main lobe axis defining a downtilt angle with respect to the earth's surface, the antenna assembly comprising:
   - a plurality of antenna means in first, second, and third antenna groups disposed along a backplane, the backplane having a longitudinal axis along which the antenna means are disposed;
   - phase adjustment means disposed between the second and third antenna groups configured to simultaneously advance a phase angle of a signal to one of said second and third antenna groups and delay the phase angle of said signal to the other of said second and third antenna groups;
   - such that adjustment of the phase adjustment means results in variation of the vertical radiation pattern downtilt angle.

2. The antenna assembly of claim **1**, wherein the second and third antenna groups each comprise a plurality of antenna means.

3. The antenna assembly of claim **2**, wherein the first antenna group comprises one antenna means.

4. The antenna assembly of claim **2**, wherein the second and third antenna groups each comprises two antenna means.

5. The antenna assembly of claim **2**, wherein each of the antenna means comprises a log-periodic dipole array.

6. The antenna assembly of claim **5**, wherein each of the log-periodic dipole array antennas comprises generally complementary front and rear dipole sections wherein one arm of each dipole is provided by the front dipole section, and the opposing arm of each dipole is provided by the rear dipole section.

7. The antenna assembly of claim **1**, wherein the backplane is a plate of conductive material.

8. The antenna assembly of claim **1**, wherein the backplane is substantially perpendicular to the earth's surface.

9. The antenna assembly of claim **1**, wherein the phase adjustment means comprises:
   - input coupling means;
   - movable coupling means having a pivotally mounted first end electromagnetically coupled to the input coupling means; and
   - transmission line means electromagnetically coupled to a second end of the movable coupling means.

10. The antenna assembly of claim **9**, further comprising drive means coupled to the movable coupling element.

11. The antenna assembly of claim **10**, wherein the drive means comprises an electric motor.

12. The antenna assembly of claim **10**, wherein the drive means is operable from a remote location.

13. The antenna assembly of claim **12**, wherein the drive means further includes means for transmitting position information relating to the phase adjustment means to the remote location.

14. The antenna assembly of claim **9**, wherein the input coupling means comprises an input coupling element formed in a T-shape from a plate of conductive material, and the input coupling element is coupled to an antenna assembly cable.

15. The antenna assembly of claim **9**, wherein the transmission line means comprises a semicircular, air-substrated transmission line section having opposing ends coupled to antenna feeder cables.

16. The antenna assembly of claim **15**, wherein the antenna feeder cables are coupled to power dividers.

17. The antenna assembly of claim **16**, wherein each of the power dividers is a microstrip transformer fabricated on a substrate of relatively low-loss dielectric material.

18. The antenna assembly of claim **16**, further comprising a first power divider coupled to the input coupling element of the phase adjusting means and to a second power divider having a plurality of outputs, each output coupled to an antenna means of the second antenna group.

19. The antenna assembly of claim **18**, wherein:
   - the phase adjustment means has a range of adjustment including a minimum downtilt position, a mid-point, and a maximum downtilt position; and
   - electrical path lengths at the operating frequency, from the input coupling means to each of the antenna means, are selected to define a progressive phase shift between each of the antenna means such that, with the phase adjustment means set at its mid-point, the vertical radiation pattern downtilt angle is approximately 7 degrees.

20. The antenna assembly of claim **19**, wherein the vertical radiation pattern downtilt angle is approximately zero degrees with the phase adjustment means set at the minimum downtilt position.

21. The antenna assembly of claim 19, wherein the vertical radiation pattern downtilt angle is approximately 14 degrees with the phase adjustment means set at the maximum downtilt position.

22. The antenna assembly of claim 1, wherein said antenna assembly further comprises an input coupling means, said phase adjustment means providing a continuously variable electrical path length between said input coupling means and said second and third antenna groups.

23. The antenna assembly of claim 22 wherein said phase adjustment means comprises transmission line means having first and second ends, and movable coupling means adjustably coupling the input coupling means to the transmission line means, whereby adjustment of said movable coupling means simultaneously decreases the electrical path length between said input coupling means and one of the first and second ends of said transmission line means and increases the electrical path length between the input coupling means and the other of said first and second ends of said transmission line means.

24. An antenna assembly having an operating frequency and a vertical radiation pattern with a main lobe axis defining a downtilt angle with respect to the earth's surface, the antenna assembly comprising:

a plurality of antennas in first, second, and third antenna groups disposed along a backplane, the backplane having a longitudinal axis along which the antennas are disposed;

a phase adjustment mechanism disposed between the second and third antenna groups, the phase adjustment mechanism including:

an input coupling element;

a movable coupling section having a pivotally mounted first end electromagnetically coupled to the input coupling element; and

a semicircular, air-substrated transmission line section electromagnetically coupled to a second end of the movable coupling section;

such that adjustment of the phase adjustment mechanism results in variation of the vertical radiation pattern downtilt angle.

25. The antenna assembly of claim 24, further comprising a drive mechanism coupled to the movable coupling element.

26. The antenna assembly of claim 25, wherein the drive mechanism is an electric motor.

27. The antenna assembly of claim 25, wherein the drive mechanism is operable from a remote location.

28. The antenna assembly of claim 27, wherein the drive mechanism transmits position information relating to the phase adjustment mechanism to the remote location.

29. The antenna assembly of claim 24, wherein:

the phase adjustment mechanism has a range of adjustment including a minimum downtilt position, a mid-point, and a maximum downtilt position; and

electrical path lengths at the operating frequency, from the input coupling element to each of the antennas, are selected to define a progressive phase shift between each of the antennas such that, with the phase adjustment mechanism set at its mid-point, the vertical radiation pattern downtilt angle is approximately 7 degrees.

30. The antenna assembly of claim 29, wherein the vertical radiation pattern downtilt angle is approximately zero degrees with the phase adjustment mechanism set at the minimum downtilt position.

31. The antenna assembly of claim 29, wherein the vertical radiation pattern downtilt angle is approximately 14 degrees with the phase adjustment mechanism set at the maximum downtilt position.

32. An antenna assembly having an operating frequency and a vertical radiation pattern with a main lobe axis defining a downtilt angle with respect to the earth's surface, the antenna assembly comprising:

a plurality of antennas in first, second, and third antenna groups disposed along a backplane, the backplane having a longitudinal axis along which the antennas are disposed;

a phase adjustment mechanism disposed between the second and third antenna groups, the phase adjustment mechanism including:

an input coupling element;

a movable coupling section having a pivotally mounted first end electromagnetically coupled to the input coupling element; and

a semicircular, air-substrated transmission line section electromagnetically coupled to a second end of the movable coupling section;

the phase adjustment mechanism having a range of adjustment including a minimum downtilt position, a mid-point, and a maximum downtilt position;

a drive mechanism coupled to the movable coupling section;

electrical path lengths at the operating frequency, from the input coupling element to each of the antennas, are selected to define a progressive phase shift between each of the antennas such that, with the phase adjustment mechanism set at its mid-point, the vertical radiation pattern downtilt angle is approximately 7 degrees;

such that adjustment of the phase adjustment mechanism results in variation of the vertical radiation pattern downtilt angle.

33. The antenna assembly of claim 32, wherein the drive mechanism comprises an electric motor drive capable of activation from a remote location, and transmitting position information relating to the phase adjustment mechanism to the remote location.

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